

WHAT IS CLAIMED IS:

1. A semiconductor device comprising:  
a gate insulating film at least part of which  
includes an insulating film containing metal, silicon  
5 and oxygen;

wherein at least one of fluorine and nitrogen is  
contained in said insulating film containing metal,  
silicon and oxygen.

2. A semiconductor device comprising:  
10 a semiconductor substrate:  
a gate insulating film provided on said  
semiconductor substrate, at least part of said gate  
insulating film including a metal oxide film;

wherein an insulating film containing metal,  
15 silicon and oxygen is provided between said  
semiconductor substrate and said metal oxide film and  
at least one of fluorine and nitrogen is contained in  
said insulating film containing metal, silicon and  
oxygen.

20 3. A semiconductor device comprising:  
a semiconductor substrate;  
a gate insulating film provided on said  
semiconductor substrate, at least part of said gate  
insulating film including a metal oxide film;  
25 wherein an insulating film containing metal,  
silicon and oxygen is formed between said semiconductor  
substrate and said metal oxide film and each of said

metal oxide film and said insulating film containing metal, silicon and oxygen is an amorphous film.

4. A semiconductor device according to claim 3, further comprising a flat insulating film having a gate opening portion in which said amorphous metal oxide film and said gate insulating film containing metal, silicon and oxygen are formed; and a gate electrode formed on said gate insulating film in the gate opening portion and having a surface which is flush with said flat insulating film.

5. A semiconductor device comprising:  
a semiconductor substrate;  
a gate insulating film provided on said semiconductor substrate, at least part of said gate insulating film including a metal oxide film;

wherein an insulating film containing metal, silicon and oxygen is formed between said semiconductor substrate and said metal oxide film and a main metal element constituting said metal oxide film and a main metal element constituting said insulating film containing metal, silicon and oxygen are different from each other.

6. A manufacturing method of a semiconductor device including a gate insulating film at least part of which includes a metal oxide film, comprising:

forming an insulating film containing metal, silicon and oxygen on a semiconductor substrate; and

forming the metal oxide film on the insulating film containing metal, silicon and oxygen.

7. A manufacturing method of the semiconductor device according to claim 6, which further comprises:

5       effecting the heat treatment at a temperature lower than a crystallization temperature of the insulating film containing metal, silicon and oxygen and higher than a crystallization temperature of the metal oxide film after said forming the insulating film  
10       containing metal, silicon and oxygen and before said forming the metal oxide film.

8. A manufacturing method of a semiconductor device including a gate insulating film at least part of which includes an insulating film containing metal, silicon and oxygen, comprising:  
15

forming a silicon oxide film series insulating film on a semiconductor substrate;

forming a metal film on the silicon oxide film series insulating film; and

20       forming the insulating film containing metal, silicon and oxygen by reacting the silicon oxide film series insulating film and metal film with each other by the heat treatment.

9. A manufacturing method of the semiconductor device according to claim 8, which further comprises:  
25

leaving part of the metal film on the insulating film containing metal, silicon and oxygen when the

insulating film containing metal, silicon and oxygen is formed.

10. A manufacturing method of a semiconductor device comprising:

5           forming a silicon oxide film series insulating film on a semiconductor substrate;

          forming a first metal film on the silicon oxide film series insulating film;

10           forming an insulating film containing silicon, oxygen and a metal element constituting the first metal film by reacting the silicon oxide film series insulating film and the first metal film with each other by the heat treatment;

15           removing part of the first metal film which does not react with the silicon oxide film series insulating film and is left behind at the time of the heat treatment; and

20           forming a second metal film formed of a metal element different from the metal element constituting the first metal film in an area from which part of the first metal film is removed.

11. A manufacturing method of a semiconductor device comprising:

25           forming a silicon oxide film series insulating film on a semiconductor substrate;

          forming a first metal film on the silicon oxide film series insulating film;

removing part of the first metal film;

forming a second metal film formed of a metal  
element different from a metal element constituting the  
first metal film in an area from which part of the  
5 first metal film is removed; and

forming a first insulating film containing silicon,  
oxygen and the metal element constituting the first  
metal film by reacting the silicon oxide film series  
insulating film and the first metal film with each  
10 other by the heat treatment and a second insulating  
film containing silicon, oxygen and the metal element  
constituting the second metal film by reacting the  
silicon oxide film series insulating film and the  
second metal film with each other by the heat treatment.

15 12. A semiconductor device comprising:

a semiconductor substrate;

first and second transistor regions formed on said  
semiconductor substrate, each of said first and second  
transistor regions having a gate insulating film at  
20 least a part of which includes an insulating film  
containing metal, silicon and oxygen;

wherein metal elements constituting said  
insulating films containing metal, silicon and oxygen  
in said first and second regions are the same and the  
25 composition ratios of the metal elements, silicon and  
oxygen of said insulating films containing metal,  
silicon and oxygen in said first and second regions are

different from each other.

13. A semiconductor device comprising:

a semiconductor substrate;

5 a first transistor region on said semiconductor substrate, in which a metal oxide film is provided as at least part of a first gate insulating film; and

10 a second transistor region in which a second gate insulating film containing metal, silicon and oxygen is provided as at least part of the second gate insulating film;

15 wherein a metal element constituting the metal oxide film in said first transistor region is the same as a metal element constituting the second gate insulating film containing metal, silicon and oxygen in said second transistor region.

20 14. A manufacturing method of a semiconductor device having a gate insulating film formed on a semiconductor substrate, the gate insulating film including first and second different regions, comprising:

forming a silicon oxide film series insulating film on the semiconductor substrate of said first region;

25 forming metal oxide films on the silicon oxide film series insulating film of said first region and on the semiconductor substrate of said second region; and

forming an insulating film containing metal,

silicon and oxygen by reacting the silicon oxide film of said second region and silicon of the semiconductor substrate with each other by the heat treatment.

15 15. A manufacturing method of a semiconductor device having first and second regions of a gate insulation film on a semiconductor substrate, comprising:

10 forming a metal oxide film on the semiconductor substrate of one of the first and second regions or on a silicon oxide film series insulating film formed at the remainder of the first and second regions;

selectively doping silicon into the metal oxide film formed on one of the first and second regions; and

15 converting the metal oxide film doped with silicon into an insulating film containing metal, silicon and oxygen.

20 16. A manufacturing method of a semiconductor device having first and second regions of a gate insulating film on a semiconductor substrate, comprising:

forming a silicon oxide film series insulating film at one of the first and second regions on the semiconductor substrate;

25 forming a metal oxide film on the silicon oxide film series insulating film;

selectively giving damage to the silicon oxide film series insulating film formed at the one of the

first and second regions; and

forming an insulating film containing metal,  
silicon and oxygen by reacting the damaged silicon  
oxide film series insulating film and the metal oxide  
5 film with each other by the heat treatment.

17. A manufacturing method of a semiconductor  
device having a metal oxide film used as at least part  
of a gate insulating film, comprising:

10 forming the metal oxide film on a semiconductor  
substrate; and

effecting the heat treatment in an atmosphere  
containing plural types of gases having different  
oxidizing powers after said forming the metal oxide  
film.

15 18. A manufacturing method of the semiconductor  
device according to claim 17, wherein the heat  
treatment is effected in a condition that metal  
contained in the metal oxide film is oxidized while  
silicon of a boundary region between the semiconductor  
20 substrate and the metal oxide film is not oxidized.

19. A manufacturing method of a semiconductor  
device having an insulating film containing metal,  
silicon and oxygen used as at least part of a gate  
insulating film, comprising:

25 forming the insulating film containing metal,  
silicon and oxygen on a semiconductor substrate; and  
effecting the heat treatment in an atmosphere



containing plural types of gases having different oxidizing powers after said forming the insulating film.

20. A manufacturing method of the semiconductor device according to claim 19, wherein the heat  
5 treatment is effected in a condition that metal contained in the insulating film containing metal, silicon and oxygen is oxidized while silicon of a boundary region between the semiconductor substrate and the insulating film containing metal, silicon and  
10 oxygen is not oxidized.